

## ***Stylogomphus sigmastylus* sp. nov., a new North American dragonfly previously confused with *S. albistylus* (Odonata: Gomphidae)**

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Key words: Odonata, dragonfly, Gomphidae, Octogomphini, *Stylogomphus*, hybridization, morphology, new species, systematics, North America.

### **ABSTRACT**

Previously, the genus *Stylogomphus* in North America was believed to contain only a single species, *S. albistylus*. We present evidence for recognizing a second species, *S. sigmastylus* sp. nov.: holotype ♂, allotype ♀: Big Swan Creek, near Gordonsburg Church of Christ, Lewis County, Tennessee, 11 June 1990, C. Cook leg., deposited in the Florida State Collection of Arthropods. The biology, distribution and morphology of the new species are described, and *S. albistylus* is re-described and figured to differentiate between the two species. *S. sigmastylus* sp. nov. males primarily differ from *S. albistylus* by having a more divaricate epiproct with widely flaring apices and a “U” shaped median cleft; shorter, thicker cerci basal of ventrolateral denticles with width and length approximately equal; ventrolateral denticles located at ca 1/3 appendage length; and posterior hamules with apex carinae thicker. The new species occurs mainly west of the Appalachian Mountains, predominantly in Arkansas, Kentucky, Missouri and Tennessee. The two species are parapatric in an area from southwestern Virginia south to North Carolina, west to northwestern Alabama and north to south-central Kentucky.

### **INTRODUCTION**

The diversity and complexity of North American Gomphidae have long interested taxonomists. Since 1950, 22 new species belonging to this family have been described in North America (Paulson & Dunkle 1999). The recognition of today's North American octogomphines, the smallest of the Nearctic Gomphidae, began when Edmond de Selys-Longchamps described *Gomphus parvulus* Selys, 1854 from a male collected in Nova Scotia (Selys 1854). Subsequently, *G. albistylus* Hagen in Selys, 1878 was described from a female specimen collected in Maine (Selys 1878). Selys (1878) also proposed the name *G. naevius* Hagen in Selys, 1878 for similar specimens from Pennsylvania, but Harvey (1898) concluded that *G. albistylus* and *G. naevius* were conspecific. Needham (1897) established the genus *Lanthus* Needham, 1897, and

designated *G. parvulus* as its generotype. Needham (1901) transferred *G. albistylus* to *Lanthus*, where it remained for fifty years (Needham & Heywood 1929; Needham & Westfall 1955), even though Fraser (1922) had established a new genus, *Stylogomphus* Fraser, 1922, for his new Indian species *S. inglisi* Fraser, 1922. Chao (1954) transferred *L. albistylus* and *L. suzukii* Matsumura, 1926 (known from Japan) to *Stylogomphus* where it has been retained in major North American Odonata works (Westfall & Tennesen 1996; Dunkle 2000; Needham et al. 2000). *Stylogomphus* is closely related to the genera *Lanthus* and *Octogomphus* Selys, 1873, the latter of which contains a single species on the Pacific slope of the North American continent (Needham et al. 2000). All three genera have been assigned to the tribe Octogomphini (cf. Carle & Cook 1984). In addition to the Nearctic *S. albistylus* (Hagen in Selys, 1878), eight Asiatic species are known from the genus (Bridges 1994).

The existence of deviant *Stylogomphus* has been known for several years (J. Belle, T.W. Donnelly, S.W. Dunkle pers. comm.), but a detailed study to establish its identity and relationship to *S. albistylus* had not been undertaken, nor had it ever been formally recognized in previous systematic works on North American Odonata. A comprehensive examination of North American *Stylogomphus* specimens revealed distinct differences in specimens from the southern and western parts of the range. *S. sigmastylus* sp. nov. is described, figured and compared to *S. albistylus*, which is also re-described and figured. A map depicting the known range of both species is also provided.

## METHODS

Data for systematics and distribution of the two species were tabulated from 362 specimens of *Stylogomphus sigmastylus* sp. nov., and 369 specimens of *S. albistylus*, held in the following institutional and private collections (see below): ANC; BMNH; CC; DRP; ELL; ETSU; FC; FSCA; GLH; INHS; JC; JFB; JJD; JS; KJT; KSNPC; KWK; RDC; RMNH; SMR; SWD; TV; TWD; UMMZ; VDC; and WFM. We feel confident these resources have included virtually all of the existent *Stylogomphus* specimens in North America. Paratypes of the new species have been deposited in the institutions and some of the private collections below. All line drawings were made with the aid of a camera lucida equipped Zeiss-Jena stereo-microscope, except Figure 23, which was computer generated using ArcView® GIS 3.2. Measurements were made with a Bausch & Lomb stereomicroscope equipped with micrometer ocular.

### Abbreviations for collectors and paratype repositories

#### Collectors

Babrakzia, N. (NB); Baumann, R.W. (RWB); Beatty, G.H., III (GHB); Bell, R. (RB); Belshe, J.F. (JFB); Belshe, R.L. (RLB); Bick, G. (GB); Blair, F.A. (FAB); Blair, W.F. (WFB); Calvert, P.C. (PPC); Chazal, A.C. (ACC); Cook, C. (CC); Curry, J. (JC); Cuyler, R.D. (RDC); Daigle, J.J. (JJD); Davis, E.M. (EMD); Donnelly, A.J. (AJD);

Donnelly, T.W. (TWD); Driver, D.D. (DDD); Dunkle, S.W. (SWD); Ferro, M.L. (MLF); Flint, O.S. (OSF); Gantt, G.J. (GJG); Gibbs, R.H. (RHG); Goldsmith, T. (TG); Green, J.L. (JIG); Harp, G.L. (GLH); Harris, M. (MH); Harvey, F.L. (FLH); Harwood, P.D. (PDH); Hobson, C.S. (CSH); Hodges, R.S. (RSH); Hornuff, L.E. (LEH); Johnson, R. (RJ); Kennedy, C.H. (CHK); Knopf, K.W. (KWK); Laudermilk, E.L. (ELL); Mauffray, W.F. (WFM); Metzler, E. (EM); Morse, R. (RM); Morse, W.J. (WJM); Paulson, D.R. (DRP); Paulson, M.L. (MLP); Robert, A. (AR); Roble, S.M. (SMR); Shiffer, C.N. (CNS); Smentowski, J. (JS); Stevenson, D. (DS); Susanke, G. (GS); Tennesen, K.J. (KJT); Thompson, F.C. (FCT); Trogon, R.P. (RPT); Vogt, T. (TV); Walker, J. (JW); Walley, G.S. (GSW); Westfall, M.J., Jr. (MJW); White, H.B. (HBW); and Williamson, E.B. (EBW).

#### Institutions containing paratypes

ANC - Academy of Natural Sciences, Philadelphia, PA  
BMNH - Natural History Museum, London, UK  
ETSU - East Tennessee State University, Johnson City, TN  
FSCA - Florida State Collection of Arthropods, Gainesville, FL  
FC - Franklin College, Franklin, IN  
INHS - Illinois Natural History Survey, Champaign, IL  
KSNPC - Kentucky State Nature Preserves Commission, Frankfort, KY  
RMNH - Nationaal Natuurhistorisch Museum Naturalis, Leiden, The Netherlands  
NMNH - National Museum of Natural History, Washington, DC  
UMMZ - University of Michigan Museum of Zoology, Ann Arbor, MI  
VDC - Virginia Department of Conservation, Richmond, VA

#### *Stylogomphus sigmastylus* sp. nov.

(Figs 1, 3-5, 12, 13, 14, 17, 19, 20)

#### Specimens examined

Holotype ♂ and allotype ♀ — United States: Tennessee: Lewis Co., Big Swan Creek near Gordonsburg Church of Christ, 11 vi 1990, CC leg., mated pair, deposited in FSCA, Gainesville, Florida (IORI-25537). Paratypes — Alabama: Colbert Co., 1 ♀, Spring Creek near Hwy 43, 11.3 km S of jct. with Hwy 72, 17 vi 1978, KJT; Lauderdale Co., 2 ♂, Butler Creek and Sour Branch at County Rd. 11, 12 vi 1983, SWD. — Arkansas: Baxter Co., 2 ♂, unnamed tributary, North Fork River, 3.2 km below Norfork Dam, 23 vi 1978, GLH; 1 ♂, same locality, 09 vii 1978, GLH; Benton Co., 1 ♂, Little Sugar Creek upstream from State Hwy 340 bridge, 29 vi 1979, GLH; Fulton Co., 1 ♀, South Fork Spring River, 9.7 km W of Hardy, 22 v 1984, GS; 2 ♀, same location, 02 vi 1990, SWD; 1 ♂, 2 ♀, Mammoth Springs, 9.7 km S on US 63, tributary of Spring River, 16 vi 1991, WFM; Garland Co., 2 ♂, 1 ♀, locality not specified, 17 vii 1960, RB; Howard Co., 1 ♂, South Fork Saline River at Rt. 70, 6.4 km W of Dierks, 20 vi 1984, SWD; Johnson Co., 2 ♂, Haws Creek Falls Rec. Area, State Hwy 123, 23 vi 1982, GLH; Montgomery Co., 1 ♀, Camp Albert Pike

Rec. Area, 14 vi 1965, WFM; 1 ♂, Caddo River, Hwy 177 near Norman, 22 v 1981, KJT; 1 ♂, Caddo Creek, 12.9 km E of Big Fork, Rt. No. 8, 04 vi 1988, RDC; 2 ♂, South Fork Ouachita River at Mt. Ida, 28 v 1981, SWD; 1 ♂, 1 ♀, Caddo River, Caddo Gap, 05 vi 1990, RDC; 1 ♂, 1 ♀, Caddo River, Caddo Springs, 04 vi 1988, RDC; 1 ♂, Caddo Creek, W of Norman, 24 vi 1990, RDC; Perry Co., 1 ♂, 1 ♀, Trace Creek at FR 86, 3.2 km SE of Hollis, 10 vi 1992, SWD; Polk Co., 1 ♂, 1 ♀, Mazarn Campground, 16 vi 1976, CC; Randolph Co., 1 ♂, Janes Creek at Hwy 90, 01 vi 1990, MJW; 1 ♂, 2 ♀, Janes Creek, Rt. 90, 1.6 km SW Ravenden Springs, 01 vi 1990, RDC; Scott Co., 1 ♀, Fourche La Fave River at Rt. 71, 30 v 1981, SWD; Sharp Co., 2 ♀, Big Creek at Hwy 67, 0.8 km S of Ash Flat, 02 vi 1990, MJW; 1 ♂, Rock Creek, Section Rd. 4.8 km N of Sitka, 03 vi 1990, RDC; Washington Co., 1 ♀, Blue Springs Rec. Area, 27 v 1974, RJH; 1 ♂, Devil's Den State Park, 18 vi 1965, WFM. — Indiana: Harrison Co., 2 ♂, Buck Creek, Elizabeth Road Bridge, 3808.7 N 8602.8 W, 09 vii 2000, JC. — Kansas: Labette Co., 1 ♂ Galesburg, tributary of Labette Creek, 17 vi 1969, LEH. — Kentucky: Adair Co., 2 larvae, Green River at Neatsville, 13 vi 1997, CC; Anderson Co., 1 ♂, Big Beaver Creek at KY 1291, 13 vi 1994, CC; Butler Co., 1 ♂, Welch Creek at Brooklyn, Hwy 340, 07 vi 1992, CC; Casey Co., 2 ♂, Green River near Dunnville, 25 vi 1990, CC; Green Co., 6 larvae, Little Barren River above Hwy 218 bridge, 21 iv 1981, CC; 1 larva, same locality, 26 iv 1999, CC; 1 larva, same locality, 06 v 1987, CC; 6 larvae, same locality, 10 v 1985, CC; 2 ♀, same locality, 15 v 1991, CC; 1 ♀, same locality, 27 v 1991, CC; 1 ♂, same locality, 03 vi 1987, CC; 2 ♀, same locality, 08 vi 1989, CC; 1 ♂, 1 ♀, same locality, 15 vi 1991, CC; 1 ♂, same locality, 28 vi 1969, CC; 3 larvae, same locality, 10 ix 1968, CC; 2 larvae, same locality, 01 xi 1998, CC; 1 ♂, 1st order tributary of Little Barren River, Bill Kidd Hollow, 28 v 1998, CC; 3 larvae, Green River at American Legion Park, Greensburg, 10 v 2000, CC; 2 larvae, Green River at Hwy 417 bridge, Greensburg, 12 iv 1999, CC; 3 larvae, Big Brush Creek at Hwy 569, 11 v 2000, CC; 2 ♂, Little Barren River ca 3.2 km downstream from East Fork/South Fork confluence, 09 vi 2000, CC & ELL; Hart Co., 7 larvae, Lynn Camp Creek, 22 iv 1999, CC; 5 larvae, same locality, 25 iv 1999, CC; 1 ♂ with exuvia, 4 ♀ with exuviae, same locality, 26 iv 1999, CC; Larue Co., 2 larvae, Thompson Creek at Raymond Peak Road, 13 vi 1994, CC; Marion Co., 1 ♂, Knob Creek along Gault Hollow Rd., 23 vi 1996, CC; Metcalfe Co., 1 larva, East Fork Little Barren River at Hwy 68, 11 v 1999, CC; 2 larvae, South Fork Little Barren River at Sulphur Well, 17 v 1987, CC; Monroe Co., 21 larvae, 9.7 km NW of Gamaliel, Sugar Creek at Hwy 100, 14 vi 1999, CC; 1 ♂, 15 larvae, Tompkinsville, 1st order stream at Old Mulkey Meeting House State Park, 14 vi 1999, CC & ELL; 2 ♂, Mud Camp Creek upstream from end of Mud Camp Creek Road, 15 vi 1998, ELL & CC; Nelson Co., 1 ♂, Mill Creek at Woodlawn, 19 vi 1980, CC; Pulaski Co., 3 ♂, Big Clifty Creek at Rd. 1676, 26 v 1993, CC; Rockcastle Co., 2 ♂, Skeggs Creek at Hansford, 17 vi 1985, CC; Russell Co., 2 ♂, Caney Creek at Wilson Road, 21 vi 1991, CC; Trigg Co., 1 ♂, 1 ♀, Casey Creek at Roaring Spring, 11 vi 1980, CC; Wayne Co., 2 ♂, Otter Creek at KY 1009, 02 vii 1964, CC. — Missouri: Carter Co., 1 ♀, locality not specified, 23 vii 1930, EBW; 1 ♀, Current River, 09 vi 1930, EBW; 1 ♂, 1 ♀, Pump Hollow, Mark Twain National Forest, 07 vi 2001, JS; Crawford Co., 1 ♂, Spring Rise, 03 vi 2000,

JW & JS; Douglas Co., 1 ♀, Moblett Creek, Hwy AP, 23 viii 1971, RWB; Hickory Co., 2 ♀, Little Niangua River, Mule Shoe Conservation Area (R20W, T36N, SEC 35), 08 vi 2000, MLF & JFB; Madison Co., 1 ♂, 1 ♀, Castor River, 18 v 2000, JW & JS; Newton Co., 2 ♂ George Washington Carver National Monument, 27 vi 1989, BK & MH; Oregon Co., 1 ♂, outlet of McCormack Lake, 07 vi 1981, SWD; Pulaski Co., 2 ♂, Bald Ridge Creek, 02 vii 2002, TV; Ripley Co., 1 ♂, Blue Flag Fen Creek, 28 vi 2002, TV; Shannon Co., 2 ♂, locality not specified, 06 viii 1930, EBW; 1 ♂, locality not specified, 08 viii 1930, EBW; Taney Co., 1 ♀, creek NE of Protom on Hwy U, 18 v 1982, JFB, RLB & NB; Washington Co., 1 ♂, Big River, 18 vi 1999, JW & JS; 1 ♂ same locality, 03 vi 2000, JW & JS. — North Carolina: Moore Co., 1 ♂, Vass, Mill Creek, 02 vii 1969, RDC. — Oklahoma: Adair Co., 1 ♂, 3.2 km W of Stillwell, 17 vi 1937, WFB & FAB; 3 ♂, 1 ♀, Baron, Barren Fork Creek, 18 vii 1970, LEH; 2 ♂, Christie, 18 vii 1970, LEH; LeFlore Co., 1 ♂, 1 ♀, Beach Creek at Rd. 246, 08 vi 1992, SWD; Ottawa Co., 1 ♀, 13.5 km N of Delaware County line, 09 vi 1961, GB. — Tennessee: Bedford Co., 2 ♂, 1 ♀, 36 larvae, Flat Creek at Ben Williams Road, 07 vi 1991, CC; Chester Co., 1 larva, 1st order tributary of Bear Creek, off Roby Trail, 16 v 1999, CC; Cumberland Co., 3 ♂, 12 larvae, Caney Fork River at Hwy 70, 8.0 km W of Crossville, 11 v 1990, CC; 2 ♂, 1 ♀, same location, 16 vi 1995, CC; 3 ♂, same location, 21 vi 1997, CC; 2 ♂, same location, 03 vii 1999, CC; 2 ♂, 3 ♀, same location, 26 v 2001, CC; 2 ♂, 1 larva, Daddy's Creek at Hwy 68, 11 vi 1993, CC; Dickson Co., 2 ♂, Will Hall Branch at Montgomery Bell State Park, E of Dickson, 10 vi 1983, JJD; 1 ♀ with exuvia, 6 larvae, same locality, 24 v 1984, CC; Fentress Co., 1 larva, Clear Creek at Hwy 127, 2.4 km S of Clarkrange, 11 vi 1961, CC; Lewis Co., 2 ♂, Gordonsburg, Swan Creek at Hwy 99, 15 vi 1982, CC; 4 ♂, 1 ♀, Big Swan Creek near Gordonsburg Church of Christ, 11 vi 1990, CC; 1 larva, Little Swan Creek 2.4 km upstream of Hwy 412, 30 iv 1993, CC; 2 ♂, 14 larvae, same locality, 07 vi 1991, CC; 10 larvae, same locality, 09 vi 1991, CC; 1 larva, Jacks Branch at Natchez Parkway, 17 vi 1993, CC; 4 ♂, 2 ♀, Swan Creek, Gordonsburg, behind church at Hwy 99, 15 vi 1982, JJD; 4 ♂, same locality, 17 vi 1982, JJD; 5 ♂, Swan Creek, Hwy 99, near Gordonsburg, KJT; 1 ♀ with exuvia, Little Swan Creek at Hwy 99, 15 vi 1983, SWD; 2 ♂, Little Swan Creek at Hwy 13, 16 vi 1984, SWD; 1 ♂, Little Swan Creek, Natchez Trace Parkway, 17 vi 1984, MJW; 1 ♂, same locality, 18 vi 1984, MJW; 1 ♂, same locality, 19 vi 1984, MJW; 5 ♂, 1 ♀, Little Swan Creek, Natchez Trace Pkwy., 09 vi 1986, KJT; mated pair, Little Swan Creek, off Natchez Parkway, 14 vi 1992, RDC; Morgan Co., 1 larva, Clear Creek, 4.8 km N of Frankfort, 05 ix 1980, CC; Perry Co., 1 ♂, Coon Creek & beaver ponds, 8.0 km W of Lewis Co. line, 14 vi 1992, SWD; 1 ♂, 1 ♀, Coon Creek, W of Hohenwald, Hwy 412, 14 vi 1992, SWD; 1 ♂, seep at Autney Hollow, 15 vii 1994, KJT; 1 ♀, field near Coon Creek, off Rt. 20 near Hickman Co., line, 13 vi 1992, RDC; Van Buren Co., 1 ♂, Cane Creek at Hwy 30, 6.4 km E of Spencer, 15 vi 1992, TWD; Wayne Co., 5 ♂, Hardin Creek, Hwy 64, 17 vi 1986, KJT; 2 ♂, 2 ♀ with exuviae, tributary of Indian Creek, Hwy 203, KJT; 1 ♂, Green River, Keazy Hollow Rd., 15 vi 1992, KJT. — Virginia: Scott Co., 2 ♂, Sorrell Creek, 0.3 km N of Bellamy and W of Rt. 643, 15 vi 1995, DS.

## Description

## Holotype male

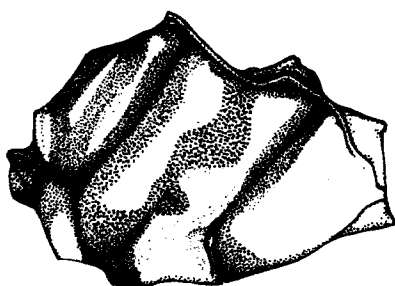
**Color:** General colors in living examples are pale green to bright yellow markings on medium to dark brown background; pale areas slightly more extensive, dark areas lacking the melanistic tent usually seen in *albistylus*.

**Head:** Labial palp grayish yellow on basal 4/5, pale yellow on distal 1/5, sparsely beset with yellow setae, laterobasal margins shallowly emarginate, lateral lobes grayish yellow with narrow external pale yellow margins, internal margin and end hooks brown; mentum widely dark brown on median, yellow laterally, squamae bright yellow; maxillae cardo and stipes yellow, inner lobe and hooks dark brown; maxillary palp brown with basal yellow stripes externally; labrum pale yellow with median 1/3 length vertical stripe and proximal margin dark brown, distal margin with median narrow dark line below carina, mandibles dark brown; anteclypeus and postclypeus largely pale yellow, twin depressions of anteclypeus with brown spots, dividing sutures with short dark dashes laterally; frons mostly pale yellow, basal 1/4 of dorsum dark brown, brown on frontoclypeal suture narrow and interrupted near median; vertex dark brown, ocellar ridge prominent and trilobed, median prominence lower and covered by a triangular yellow spot; antennae dark brown, scape with distal yellow annulus; anterior surface of occiput dark brown with median triangular yellow spot, posterior surface widely yellow medially, dark laterally; rear of head entirely brown, shading from tan near the neck to very dark brown at juncture with compound eyes.

**Thorax:** Prothorax dark brown marked with yellow, anterior carina of pronotum widely yellow, dorsum brown with twin medial spots, lateral margins with sigmoid yellow spots covering 'shoulders'; posterior lobe brown; postepimeral stripe yellow with median and carinae brown; proepimeron brown medially, anterior and lateral margins widely yellow; proepisternum largely yellow. Pterothorax (Fig. 1) with pattern of alternating dark and light stripes typical of genus, dark areas slightly less extensive than in *albistylus*; mesotergum medially yellow, margined with brown,



1



2

Figures 1, 2: Pterothoracic color pattern of *Stylogomphus sigmastylus* sp. nov. (Fig. 1) and *S. albistylus* (Fig. 2)

adjacent sclerites mostly brown with a slight brush of yellow along dorsolateral margins; mesothorax largely dark brown, middorsal carina narrowly yellow from lower margin of collar to angulation point, then entirely brown to bifurcation above; anterodorsal collar with yellow band 0.4 mm wide, narrowing laterad and interrupted at median by wedge of brown; mesanepisternal yellow stripes ca 2.0 x 0.5 mm, divergent anteriorly, not confluent below with yellow collar, above just reaching basal antealar carina; mesanepisternal lateral yellow stripes narrowed at upper 2/5 but usually not divided, a circular expansion above not reaching antealar carina, not conjoined below with yellow sternopleurites; episterna and epimera yellow medially, with bordering sutures dark brown, dark humeral stripe ca 0.7 mm wide above, narrowing below to ca 0.5 mm, where it is widely conjoined with interpleural stripe; dark interpleural stripe widened above and angled at upper 1/3, usually not encircling spiracle; dark metapleural stripe widened medially and below, enclosing a pale median slash; dorsolateral carina and antealar sinus dark brown; thoracic venter pale yellow.

**Legs:** Coxae entirely pale yellow; trochanters brown laterally, flexor surface pale yellow; prothoracic femora brown laterally, flexor surface pale yellow; tibiae dark brown, keel pale yellow, 0.6 mm long and ca 1/4 tibial length; tarsi dark brown; pterothoracic femora, tibiae, and tarsi brownish black, hind tibiae 5.1 mm long.

**Wings:** Venation slightly more open with fewer intercalated cells than in *albistylus* and largely blackish; costa and margins of Pt dark brown, Pt membrane tan; Fw Ax 10-10, Hw 7-7; Fw Px 6-7, Hw 7-7; triangles, subtriangles and supratrangles without crossveins; basal subcostal crossvein absent; Fw triangle moderately angulated at ca 1/3 length from M4, and posterior angulation of both Fw and Hw triangles more pronounced than in *albistylus*; bridge crossveins 3-4/3-3.

**Abdomen:** Color: pale areas slightly more extensive than in *albistylus*; brownish-black marked with yellow, pale areas on S1 pale yellow on dorsum, dorsolateral 1/3 brown, ventrolateral 2/3 and entire venter pale yellow; S2 dorsum dark brown with full length dorsomedian bright yellow stripe, anterior dorsolateral 2/3 dark brown, auricles yellow, surrounded by yellow slash, posterior ventrolateral 1/3 and ventral carinae bright yellow, venter and genitalia largely dark brown; S3 with laterobasal yellow spots ca 1/8 length of segment and not connected across meson, carinae pale yellow, venter brown; S4-7 colored as in S3 except yellow extends across meson to completely encircle segments; S8 with entire meson brown, anterior ventrolateral half with yellow quadrangle, brown on posterior ventrolateral half, ventral carinae narrowly brown, venter brown; S9 marked similar to S8, except anterior yellow spot smaller, and brown along ventral carinae wider, venter cream colored with brown sternites; S10 completely black; intersegmental conjunctivae between all segments usually bicolored, brownish basally and yellowish apically. Expansion of posterior segments is minimal and ventral foliaceous margins are rudimentary.

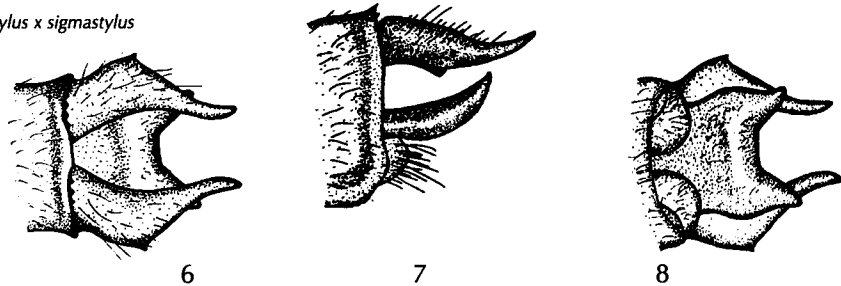
**Terminalia:** Shapes of the cerci and epiproct are distinctive in *sigmastylus*. Cerci compared with *albistylus* thicker throughout; largely yellow with narrow brown basal border extending along ventrolateral margin to include the denticle; in dorsal view (Fig. 3) sigmoid, basal section proximad of ventrolateral denticle prominently wide, short and turned outward, at ca 1/4 length sharply angled and expanded

ventrolaterally into an acuminate denticle, beyond denticle incurved to ca 3/4 length, slender apical 1/4 directed slightly outward; in lateral view (Fig. 4) basal half sloped downward, ventrolateral denticle at ca 1/3 length and apical half slightly upturned, total length 1.3 mm, width at base 0.29 mm, width at ventrolateral denticle 0.41 mm, basal thickness approximately 1/3 appendage length. Epiproct compared with *albistylus* wider than long, lateral lobes widespread with blunt tips, the median cleft "U" shaped and shallow; in ventral view (Fig. 5) brown, upturned apical denticles darkest, venter swollen, sparsely covered with minute setae, widening toward apex, the apical lobes short with rounded tips; length 0.73 mm, apical tip spread 1.0 mm, and depth of median cleft 0.18 mm; in lateral view (Fig. 4) epiproct reaches to approximately 2/3 length of cerci, base thickened, median hump appearing as an angle in ventral outline, tip obliquely truncated with apical denticles slightly upturned.

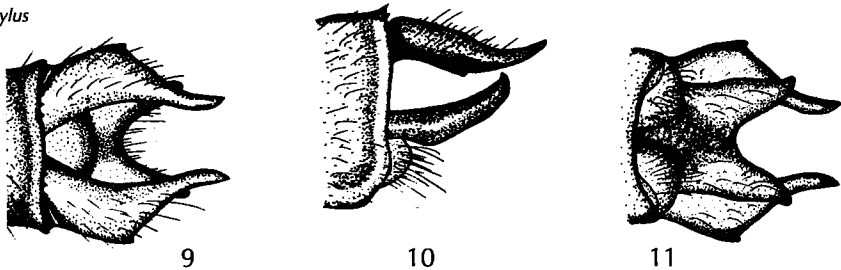
*S. sigmastylus*



*S. albistylus* x *sigmastylus*

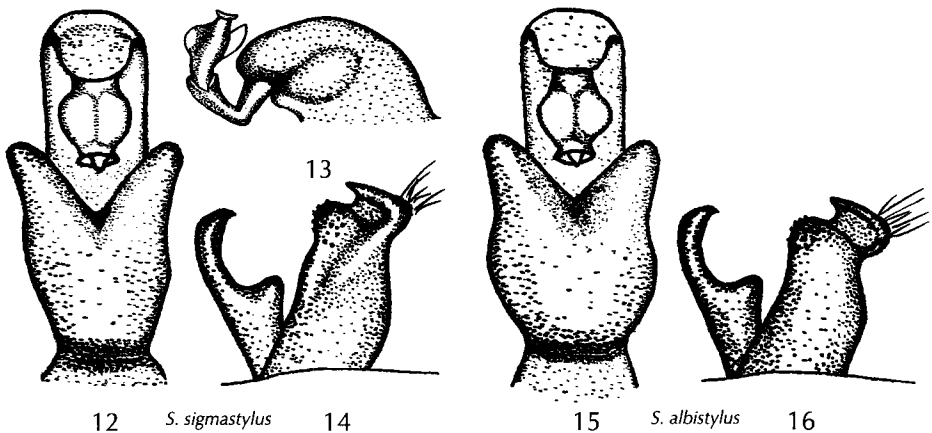


*S. albistylus*



Figures 3-11: Adult male terminalia of *Stylogomphus sigmastylus* sp. nov., *S. albistylus* x *sigmastylus* and *S. albistylus* — dorsal, lateral and ventral view.





Figures 12-16: Male secondary genitalia and penis vesicle of *Stylogomphus sigmastylus* sp. nov. and *S. albistylus* — ventral view of penis vesicle (Figs 12, 15), lateral view of penis vesicle (Fig. 13) and lateral view of male secondary genitalia (Figs 14, 16).

**Secondary Genitalia:** Anterior and posterior hamuli brown; anterior hamules in lateral view bilobed (Fig. 14), typical of classical gomphid ‘thumb and knuckles’ type; anterior lobe thinnest, apex decurved and hook-like, posterior lobe wider with rounded apex, large oval excavation between lobes occupying ca 1/3 appendage length; posterior hamules in oblique lateral view (Fig. 14) directed mesoventrally, shoulder rounded, tumid, setose and beset with 12-17 low denticles, raised transverse ridge at shoulder bent abruptly into a depressed lobe or ‘neck’ which is transversally excavated across lobe and bordered externally around apex by a thickened carina, apex of lobe widely truncated, the bordering thickened carina ends in a mesad directed acuminate spine and ventrad directed tuft of stiff setae; penis vesicle in lateral view (Fig. 13) exceptionally large and rather simple in *Stylogomphus* compared to most other gomphid genera; in ventral view (Fig. 12) anterior of vesicle is more deeply cleft with longer lobes than *albistylus*, lateral flaps of third joint are globular and conspicuously white.

**Measurements [mm]:** Total length 36.5; abdomen 28.5; cerci 1.3; epiproct length 0.73, width 1.0, depth of cleft 0.18; hind femora 5.1; Hw 21.5; Pt 2.5-2.5/2.6-2.65.

Allotype female

**Color:** Patterns as in male, dark background slightly lighter shade of brown.

**Head:** Vertex shaped similar to male, ocellar ridge prominent, lateral oblong sections slightly wider and more elevated than in *albistylus*, median “V” shaped section bold and produced forward, rounded humps adjoining ocelli bold and wide-based, their apices reaching the highest point on vertex, a low secondary ridge laterally reaching compound eyes; median pale spot sometimes more extensive than in *albistylus*; vertex sculpturing less uniform than in *albistylus*, and shows considerable variation in different populations of *sigmastylus*.

**Thorax:** Prothorax and pterothorax markings similar to male, brown shades slightly paler; interpleural stripe somewhat reduced, median pale area more extensive.

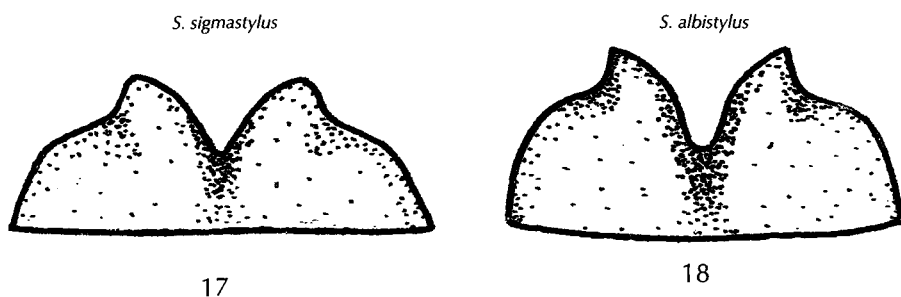
**Legs:** Coxae and trochanters colored as in male; middle femora yellow medially on basal 2/3, hind femora basally yellow both laterally and medially for 3/4 of their length.

**Wings:** Fw Ax 11-12, Hw 8-8; Fw Px 8-9, Hw 7-7; triangles, subtriangles, and supratrangles free, except for half-length crossvein in one front subtriangle; angulation of front triangles as in male, Hw triangles curved in distal 1/3, but not distinctly angled; bridge crossveins 4-4/3-4.

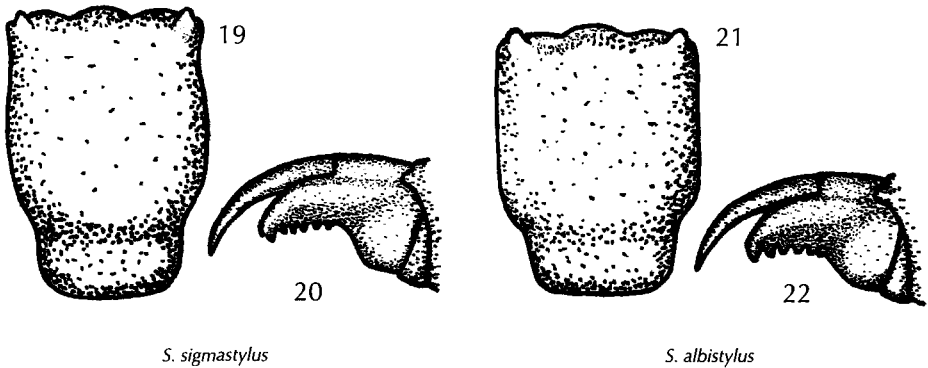
**Abdomen:** Anterior dorsum brown, becoming blackish toward terminal segments, pale colors more extensive than in male; S1 largely yellow, with twin dorsolateral quadrangular brown spots not connected across meson, entirely yellow ventrolaterally and on venter; S2 brown dorsum divided by full length mesal yellow stripe, entirely yellow ventrolaterally; S3 brown except for laterobasal quadrangular yellow which reaches to transverse carinae, the mesal dividing line reduced to a short anterior dash; S4-6 brown on dorsum, laterobasal yellow spots reduced to ca 1/4 segment length; S7 with laterobasal yellow area reaching half length and expanded anteriodorsally to encircle segment; S8 laterobasal yellow area reaches half length, a small yellow basal dash on brown dorsum; S9 blackish, laterobasal yellow reaching ca 1/3 segment length; S10 all blackish except narrow pale foliaceous margin; cerci yellow, acuminate and ca 1 1/4 length of S10, not distinctive from *albistylus*.

**Genitalia:** Vulvar lamina dark brown (Fig. 17), ca 1/5 length of S9 sternum, flap-like, not inflated, not elevated above sternum, and usually with apices closely contacting ventral sternum; bilobed, with "V" shaped cleft between lobes, the apices blunt and not turned outward; in *albistylus* cleft is "U" shaped with the apices acute and turned outward (Fig. 18). These characters are less apparent in lateral view, or when S9 sternum is compressed.

**Measurements [mm]:** Total length 36.8; abdomen 27.18; cerci 0.82; hind femora 5.5-5.8; Hw 22.0; Pt 2.8-2.8/3.3-3.2.



Figures 17, 18: Vulvar lamina of *Stylogomphus sigmastylus* sp. nov. (Fig. 17) and *S. albistylus* (Fig. 18) — ventral view.



Figures 19-22: Prementum and labial palps of *Stylogomphus sigmastylus* sp. nov. and *S. albistylus* — ventral view of larval prementum (Figs 19, 21) and ventral view of larval labial palp (Figs 20, 22).

#### Larva

**Head:** Antenna typical of genus, segment 3 triangular-ovoid, widest proximally and narrowing toward a rounded apex, mesal margin straight and contiguous with opposing antenna, body thin mesally and surrounded outwardly with an elevated carina margined with short flat setae; segment 4 vestigial, represented by a low rounded tubercle; prementum (Fig. 19) longer than wide (ratio of ca 9 to 10), with lateral margins more convex and narrowed basal section longer and less abruptly narrowed than in *albistylus*; ligula convex, front margin fringed with stiff setae and usually beset with 2-4 small, tooth-like denticles; labial palp (Fig. 20) usually has a prominent 'double-pointed' distal tooth followed by 5-6 triangular teeth set in a relatively straight row; overall width of palp narrower and basal internal lobe less prominent than in *albistylus*.

**Abdomen:** Ovoid, dorsum granular, but virtually devoid of setae; widest at S6, then abruptly narrowing at S9 and beyond; mature wing pads reach to mid-length of S4; median depressed groove shallow, terminating at mid-length of S8; a broad median ridge on S9 with shallow lateral depressions on each side; small lateral spines acute on S8 and blunt on S9; without spines on S7.

**Terminalia:** Short and triangular, paraprocts longest; length relative to middorsal length of S10: cerci ca 1 1/4 times longer; epiproct ca 2.0 times longer; and paraprocts ca 3.0 times longer.

**Measurements [mm]:** Total length 16.8-18.4; abdomen 10.5-12.6;  $n = 98$ .

#### Variation

As is common in the Gomphidae, considerable morphological variation was observed. Table 1 delineates the range of measurements for selected morphological characters in the male, female and larva of the new species.

Table 1. Range of measurements for *Stylogomphus sigmastylus* sp. nov. [mm].

Morphological character	male (n=131)	female (n=53)	larva (n=98)
Total length	34.9 - 37.1	35.1 - 37.6	16.8 - 18.4
Abdomen length	27.0 - 29.4	26.98 - 30.08	10.5 - 12.6
Hw length	20.6 - 23.3	21.4 - 23.9	-
Epiproct spread	0.97 - 1.1	-	-
Epiproct cleft depth	0.16 - 0.19	-	-

### Diagnosis

*S. sigmastylus* males are readily distinguishable from *S. albistylus* by shape of the abdominal appendages and accessory genitalia (Table 2). For females and larvae distinguishing characters are fewer and less apparent. For females shape of the vulvar lamina is most useful, and for larvae shape of the prementum and labial palp are the most distinctive characters (Table 2).

### Etymology

From "sigma" Gr. = letter "S" in Greek alphabet, and "stylus" L. = "sharp-pointed", alluding to the sharp-pointed "S" shaped cerci. The specific epithet is an adjective.

### Biology and habitat

*S. sigmastylus* larvae inhabited sandy, still-water pockets near rocky riffles of relatively clean, small (3-5 m wide) and moderately sized (10-20 m wide) forested streams with a moderate gradient and various combinations of sand, gravel, cobble and boulder substrates. Emergence occurred on boulders or on sandy banks 5-20 cm from the water's edge. Adult males perched on sunny boulders in mid-stream or along the water's edge. They were rather wary at rest, and would quickly dart away if disturbed. Their flight was close to the water and difficult to detect. When disturbed they would frequently fly out over a shallow riffle, and quickly returned to perch on the same boulder. Flight season was from late April (Kentucky) to late August (Missouri).

### *Stylogomphus albistylus* (Hagen in Selys)

(Figs 2, 9-11, 15, 16, 18, 21, 22)

### Specimens examined

The holotype is in the Museum of Comparative Zoology, Cambridge Massachusetts, but is in poor condition, so was not examined. — Alabama: Blount Co., 11 larvae, Blount Springs, Mill Creek at Rd. 5, 01 v 1993, CC; 12 larvae, Blount Springs, Mulberry Fork River, 01 v 1993, CC; 16 larvae, Locust Fork River at Hwy 79, 01 v 1993, CC; 4 larvae, Blue Springs Creek at Rd. 55, Blountsville,

28 iii 1992, KJT; 1 ♂, Locust Fork at Hwy 231, 4.8 km S of Blountsville, 15 v 1990, KJT; Chilton Co., 1 ♂, Crawford Creek, 0.97 km E of Hwy 145, 02 vi 1982, KJT; 1 ♂ with exuvia, emerged 12 iv 1994; Cleburne Co., Shoal Creek, Pine Glen Rec. Area, 23 iii 1994, KJT; Colbert Co., 1 ♂, Buck Branch Riverton Rose Road, 27 iii 1998, KJT; Lawrence Co., 1 ♀, Shoal Creek at Rd. 8, 12 vi 1983, SWD; Marion Co., 2 ♂ with exuviae, emerged 01 v 1995, North Fork Creek, Hwy 43, 14 iv 1995, KJT and 3 ♀ with exuviae, emerged 03 v 1995, KJT; 1 ♂ with exuvia, emerged 11 v 1995, Buttahatchee River at Hwy 278, 28 iv 1995, KJT; Tuscaloosa Co., 1 ♂ with exuvia, reared and emerged 09 iv 1938, locality not specified, 06 ii 1938, collector not specified; 1 ♂, locality not specified, 25 iv 1938, collector not specified; 1 ♂, Cooley Creek, 05 v 1939, RSH; 1 ♂, 1 ♀, same locality, 06 v 1939, RSH; 1 ♂, same locality, 10 v 1939, RSH; 1 ♀ with exuvia, reared, same locality, RSH; 1 ♂, same locality, 11 v 1939, RSH; 1 ♂ with exuvia, reared, same locality, 12 v 1939, collector not specified; 2 ♂ with exuviae, reared, same locality, 14 v 1939, collector not specified; 1 ♂, same locality, 16 v 1939, collector not specified; 2 ♂, 1 ♀ with exuvia, reared, locality not specified, 21 v 1938, collector not specified; 1 ♂ with exuvia, reared, Cooley Creek, 26 vi 1938, RSH; Winston Co., 1 ♀, locality not specified, 11 vi 1983, SWD. — Georgia: Habersham Co., 1 ♂, Nancytown Lake at creek near Cornelia, 28 v 1979, JJD; 1 ♂, Nancytown Lake, 28 v 1979, SWD; Walker Co., 1 ♂, E Armuchee Creek, 14 vi 1979, SWD; White Co., 1 ♀, Dukes Creek at Hwy 75, 07 vi 1979, KJT. — Kentucky: Bell Co., 4 larvae, Calvin, Hinces Creek, 23 viii 1979, CC; Breathitt Co., 3 larvae, Middle Fork Kentucky River at Upper and Lower Twin creeks, 11 viii 1999, CC & ELL; Carter Co., 1 ♂, Buffalo Creek at Wesleyville, 09 vi 1985, CC; 4 larvae, East Fork Little Sandy River at KY 854, 18 v 1997, CC; Clay Co., 1 ♂, South Fork Kentucky River at Rocky Branch Road, 10 viii 1999, CC & ELL; Green Co., 2 ♂, Green River at Greensburg, 16 vi 1958, CC; 1 ♂, Little Barren River, 0.48 km below Hwy 218 bridge, 28 vi 1969, CC; Greenup Co., 4 larvae, Tygarts Creek at Benetts Mill, 18 v 1997, CC; Harlan Co., 3 larvae, Bledsoe, 03 ix 1960, CC; 1 ♀, Laurel Fork ca 0.3 km upstream from Trace Branch, 08 vii 1996, ELL; 1 ♀, Big Laurel Creek at Young's Branch, 09 vii 1996, ELL; Letcher Co., 3 larvae, Blackey, North Fork Kentucky River, 03 x 1986, CC; 1 ♀, Poor Fork Cumberland River ca 0.3 km downstream from beaver pond, 20 vi 2001, CC & ELL; McCreary Co., 1 ♂, Bell Farm, Rock Creek, 27 v 1959, CC; Powell Co., 1 ♂, Stanton, 16 vi 1960, RJ; 2 larvae, Upper Hood Branch, 16 v 1995, ELL; Whitley Co., 1 ♂, Rockholds, Watts Creek, 06 vi 1969, CC. — Maine: Aroostook Co., 1 ♂, tributary of Machias River, 29.0 km W of Ashland, 19 vii 1982, TWD; Penobscot Co., 2 ♂, Chanes Mill, Bradley, 04 vii 1899, FLH; 1 ♂, Orono, date not specified, FLH, 1 ♀, Orono, date and collector not specified; Piscataquis Co., 1 ♀, vicinity of Little Pillsbury and Haymock Lake, 20-21 vii 1982, TWD. — Maryland: Caroline Co., 1 ♂, near Williston, date not specified, TG. — Massachusetts: Middlesex Co., 1 ♂, Shirley, 09 vii 1939, EMD; 1 ♂, Squannanook River, Townsend Harbor, 22 vi 1969, HBW; 3 ♂, 1 ♀, Groton, Townsend Road, Bertozzi-Squannanook Wildlife Management Area/Groton Conservation Area, 08 vii-14 viii 1989-1991, SMR; 1 ♂, Willard Brook at Willard Brook State Forest, 13 vi 1976, collector not specified. — Michigan: Baraga Co., 3 ♂, Tioga Creek at Rd. 28, 20 vii 1983, SWD; Delta

Co., 1 ♂, Escanaba River, 1.6 km E of Cornell on Hwy 519, 19 vi 1991, TWD; Dickinson Co., 2 ♂, Sturgeon River, Rt. 2 E of Norway, 27 vi 1991, RDC; Iron Co., 1 ♀, North Branch Paint River Rd. 16, 10 vii 1984, KJT; Montmorency Co., 5 ♂, East Fish Lake at outlet, 14 vii 1983, SWD; Ontonagon Co., 3 ♂, 3 ♀, West Branch Ontonagon River at Rt. 28, 23 vii 1983, SWD. — New Hampshire: Coos Co., 1 ♂, stream 8.0 km S of Lancaster on 3, 18 vii 1982, SWD; Merrimack Co., 1 ♀, Franklin, Rt. 127 S, 21 vi 1964, FCT; Strafford Co., 2 ♂, 1 ♂, Belamy Dam in Madbury, 03 vii 1971, RM; 2 ♂, Durham, 08 vii 1951, WJM. — New Jersey: Morris Co., 1 ♂, Black River, Hacklebarney State Park, 21 vi 1959, collector not specified; Somerset Co., 2 ♂, 1 ♀, North Branch Raritan River near Far Hills, 14 vii 1951, CC. — New York: Chenango Co., 1 ♂, Geneganslet Creek, 4.8 km N of Smithville Flats, 18 viii 1984, TWD; 3 ♂, Chenango River, Rt. 23, Norwich, 18 vii 1999, RDC; Essex Co., 1 ♂, 1 ♀, Schroon River, Sharp Bridge Campground, 12.9 km N of North Hudson, 03 vii 1995, TWD; Hamilton Co., 1 ♂, Bug and Eagles Nest Lakes, Raquette Lake, 31 vii 1974, HBW; Schuyler Co., 1 ♂, Catherine Creek, near Montout Falls, 10 v 1953, reared and emerged 25 v, RHG; 1 ♀ with exuvia, reared, same locality, emerged 01 vi 1951, collecting date not specified, RHG; 1 ♀ with exuvia, same locality, collecting and emergence date not specified, RHG; St. Lawrence Co., 1 ♂, Oswegatchie, 25 vi 1946, MJW; 1 ♀, same locality, 28 vi 1946, MJW; Steuben Co., 1 ♂, Willseyville, 30 v 1953, TWD; Tioga Co., 1 ♀ with exuvia, reared and emerged 11 v, Willseyville, 23 iv 1954, RHG; 1 ♂, 1 ♀, Willseyville, 30 v 1953, TWD; 1 ♂, reared and emerged 12 vi 1967, E Branch Owego Creek, at Richford, 28 v 1967, TWD; Tompkins Co., 1 ♂, reared and emerged 10 vi, Cascadilla Creek, 30 v 1954, RHG; 1 ♀, reared and emerged 27 v, Willseyville Creek at Willseyville, 17 v 1953, RHG; 1 ♀, reared and emerged 29 v, same locality, same date, RHG; 1 ♀, stream 3.2 km SW of Danby, 20 v 1954, JIG. — North Carolina: Avery Co., 1 ♀, Lindville, Lindville River, 16 viii 1978; 2 ♀, same location, 17 vi 1991, RDC; Burke Co., 1 ♂, near Morganton, stream at Table Rock Fish Hatchery, 15 vi 1967, GJG; Caldwell Co., 1 ♂, Wilson Creek, Sec. Rd. #1337, 5.8 km W of Rt. 90, Collettsville, 04 vi 1994, RDC; 1 ♂, 1 ♀, Wilson Creek, Sec. Rd. #1328, 7.2 km N of #1337, 04 vi 1994, RDC; Caswell Co., 1 ♀, rivulet near County Line Creek, Rts. 86-158, S of Yanceyville, 24 v 1996, RDC; 1 ♂, rivulet flowing into County Line Creek, Rts. 86-158, S of Yanceyville, 15 v 1991, RDC; Chatham Co., 1 ♀, Rocky River at Rts. 501-15, 22 v 1974, KWK; Guilford Co., 1 ♀, 3.2 km SE of Monticello, 28 v 1987, RDC; Haywood Co., 1 ♂, Pigeon River, at Rt. 110, 28 vi 1990, RDC; Macon Co., 1 ♂, Highlands, Turtle Pond Bridge, 14 vii 1953, MJW; 2 larvae, Hurricane Creek near Nantahala River, 15 km SW of Franklin, 05 ix 1993, CC & TV; Madison Co., 1 ♂, marsh near small stream at Rt. 208, 1.6 km E of TN state line, 18 viii 1996, RDC; 1 ♀, Laurel Creek, Rt. 208-212, 4.8 km NE of Jct. Rt. 25-70, 09 vi 1994, RDC; Moore Co., 1 ♀, Vass, Mill Creek, 02 vii 1969, RDC; 1 ♀, same locality, 03 vi 1968, RDC; 1 ♂, Mill Creek at Hwy 1 bridge, S of Vass, 15 v 1983, CC & SWD; Orange Co., 1 ♀, Duke Forest (Korstian Div.), 01 vi 1986, RDC; 1 ♂, reared and emerged 22 iv, Morgan Creek at NC 54, 28 iii 1965, DRP; 2 ♀, same locality, 29 v 1966, DRP & MLP; Rutherford Co., 1 ♂, West Fork French Broad River at Hwy 64, 06 viii 1989, SWD; Transylvania Co., 2 ♂, Brevard, 03 viii 1941, MJW; 2 ♂, stream near Pisgah

Forest, 20 vi 1939, MJW; 1 ♂, same locality, 17 viii 1941, MJW; 1 ♂, same locality, date not specified, MJW; Yancey Co., 1 ♂, NC 197, North Toe River, 08 vii 1988, RDC; 1 ♂, Toe River, 2.7 km downstream of Busick, 11 vi 1958, TWD. — Ohio: Ashland Co., 1 ♂, Ball Run, 01 vii 1956, PDH; 2 ♀, creek at Rt. 3 X Clear Fork, 11 vi 1939, CHK; 1 ♂, stream entering Mohegan River, 20 June 1955, PDH; 1 ♂, Mohegan River near Ball Run, 08 vi 1959, PDH; 2 ♂, Mohegan State Park, 25 vi 1966, PDH; 1 ♂, same locality, 24 vi 1967, PDH; 2 ♂, same location, 26 vi 1945, PDH; Franklin Co., 1 ♂, Black Lick Creek, 07 vi 1924, CHK; Holmes Co., 1 ♂, Nashville, 23 vi 1963, collector not specified; Miami Co., 1 ♂, Clear Fork State Park, 25 vii 1965, PHD; 1 ♂, Clear Fork at Pleasant Hill Dam, 22 vi 1963, PDH; Vinton Co., 1 ♂, 1 ♀, Little Raccoon River, 23 v 1970, EM. — Pennsylvania: Bucks Co., 1 ♀, Unami Creek near Finland, 04 vi 1954, GHB; 1 ♂, Tinicum Creek, 03 vii 1953, GHB; 1 ♂, same location, 01 viii 1947, GHB; Centre Co., 1 ♀, Penn's Creek at Poe Paddy Park, 25 vi 1959, TWD; Chester Co., 1 ♀, West Chester, 30 v 1899, PPC; Clinton Co., 2 ♂, Kittle Creek on Rt. 144, N of Tamarack, 21 vi 1986, SWD; 4 ♂, 2 ♀, same locality, 21 vi 1986, KJT; Huntingdon Co., 2 ♂, Beaver Dam meadow, 3.2 km NW of Whipple Dam, 22 vi 1986, SWD; 1 ♂, 1 ♀, same locality, same date, KJT; 1 ♀, E end of Whipple Dam State Park, small stream, 23 vi 1986, SWD; 1 ♂, Whipple Dam, 08 vii 1982, TWD; Perry Co., 1 ♀, Little Juniata Creek, New Bloomfield Rd. 2, 10 vii 1966, CS; 1 ♀, Shermansdale, Shermans Creek, 13 vii 1965, CS; Potter Co., 5 ♂, Old Bull State Park, 28 vii 1973, MJW; Somerset Co., 4 ♂, Rockwood, 29 vi 1900, EBW. — Tennessee: Cocke Co., 1 ♂, Wolf Creek near French Broad River at US 70, 31 vii 1960, RPT; Monroe Co., 1 ♀, North River, 25.7 km E of Tellico Plains, 14 viii 1986, KJT; 1 ♀ with exuvia, reared and emerged 19 v 1998, North River 5.3 km up North River Road, 04 v 1998, KJT; Sevier Co., 3 ♀ with exuviae, reared and emerged 03 iv 1998, Caney Creek SE of Pigeon Forge, 01 iv 1994, KJT; Sullivan Co., 2 ♂, 2 ♀, Bays Mountain Lake near Johnson City, 09 viii 1989, OSF. — Vermont: Essex Co., 2 ♀, outlet of McConnell Pond at 105, 9.7 km E of Island Pond, 14 vii 1982, SWD; 3 ♂, same locality, 15 vii 1982, SWD. — Virginia: Bath Co., 1 ♂, 1 ♀, Cowpasture River at Rd. 39, 28 vi 1982, SWD; 1 ♂, Cowpasture River at County Rt. 629, 09 vi 1999, SMR; 1 ♂, Hidden Valley, Jackson River, 10 viii 1994, SMR; 1 ♂, Little Wolf Creek along Appalachian Trail at Forest Road 282 crossing, 11 viii 1993, CSH; Bland Co., 1 ♀, stream near Rocky Gap, 26 vi 1956, RDC; Botetourt Co., 1 ♀, Craig Creek at the James River, 27 vi 1982, SWD; Dickenson Co., Pound River, 12 vii 1995, CSH; Giles Co., 1 ♂, Hoges Store, 01 vii 1951, DDD & GHB; Prince William Co., 1 ♀, Manassas National Battlefield Park, Stone House/Young's Bridge, 27 v 1999, ACC; Pulaski Co., 4 ♂, Walker Creek, Rt. 100 just S of Poplar Hill, 26 vi 1973, SWD; Rockbridge Co., 2 ♂, Mill Creek along Rt. 39/42, 0.8 km E of Bath County line, 10 viii 1994, SMR; Shenandoah Co., 1 ♂, Passage Creek at Elizabeth Furnace, George Washington National Forest, 17 vi 1969, TWD; Washington Co., 1 ♀, Craige Mill, Smith Creek at confluence with Gaspard Creek adjacent to Rt. 614, date not specified, DS; 1 ♂, Nordyke Creek at Rt. 622/616, date not specified, DS; Wythe Co., 1 ♂, Wytheville, 07 vii 1963, AJD. — West Virginia: Gilmer Co., 4 larvae, Sycamore Creek, Glenville, 09 vi 1986, PDH; Grant Co., 3 larvae, Greenland Gap, 16 v

1974, PDH; Greenbrier Co., 1 ♂, Greenbrier River at Rt. 60, 06 viii 1982, SWD; 2 ♂, same location, 23 vi 2002, CC; 1 ♀, with exuvia, Roncervrte, emerged 04 v 1974, collecting date not specified, PDH; Hampshire Co., North River at 45, 07 vi 1976, KWK; 1 ♂, Cacapon River, 3.2 km SW of Capon Bridge, 30 vi 1989, TWD; Monroe Co., 1 ♂, Rich Creek, 6.4 km NE of Peterstown, 18 vi 1992, TWD; Nicholas Co., 1 larva, Woodbine Camp, Richwood, 07 viii 1974; Pendleton Co., 1 ♂, South Branch Potomac River at mouth of Seneca, Seneca Rocks, 03 vii 1989, collector not specified; 2 ♀ with exuviae, 21 v 1972, PDH; Pocahontas Co., 1 ♂, Spruce, 08 viii 1971, PDH; Preston Co., 1 larva, Terra Alta, Salt Lick Run, 25 vi 1975, PDH; Randolph Co., 4 ♂, 2 ♀, 6 larvae, 34 exuviae, Shavers Fork Cheat River, Cheat Bridge at Hwy #250, 25 vi 2002, CC; Tucker Co., 1 ♀ with exuvia, Alder Creek, Dolly Sods, 24 vi 1974, PDH; Wood Co., 10 larvae, Bull Creek, Borland Springs, 12 viii 1973, PDH; —Wisconsin: Forest Co., 3 ♂, Swamp Creek, Swampy Lane, 30 vi 1994, KJT; Price Co., 2 ♂, Elk River at Co. Rd. S, 16.1 km W of Phillips, 20 vi 1988, KJT. — Canada: New Brunswick: Charlotte Co., 1 ♂, Canoose Stream, 19.3 km N of St. Stephen on Hwy 745, 18 vii (year not specified), TWD. — Ontario: Algoma Co., 2 ♂, Searchmont, 06 viii 1906, EBW; Cochrane Co., 1 ♀, Departure Creek, 01 viii 1953, collector not specified; Renfrew Co., 1 ♂, Bark Lake, 23 vii 1939, collector not specified. — Quebec: Joliette Co., 1 ♀, Lec Sylvere, 20.9 km NE of St. Donat, 2-8 viii 1973, TWD; Labelle Co., 1 ♀, Decharge du lac des femmes, Parc du Mont Tremblant, 26 vi 1954, AR; county not specified, 1 ♂, Covey Hill, 12 vii 1924, GSW; county not specified, 2 ♂, Verendrye National Park, inlet of Lac Foucard, 09 vii 1982, SWD.

### Re-description

#### Male

**Color:** Body colors of living examples have pale gray to bright yellow markings on a brown background, mesothoracic and abdominal dorsal surfaces show a distinctly melanic overcast on brown areas; pale markings slightly less extensive than in *sigmastylus*.

**Head:** Labium dark gray basally, paler gray distally, densely beset with brown setae on apical 1/4, laterobasal margins more excavate, lateral lobes with median grayish area reduced, pale yellow lateral margins widened to ca 1/2 lobe width, brown on proximal surface more extensive, end hooks all brown; mentum dark brown medially and yellow laterally; maxillae cardo yellow, stipes yellow proximally and darkening externally, terminus and hooks brown; maxillary palp brown proximally, with external yellow stripe; labrum pale yellow, proximal margins dark, and with or without a brown vertical dividing stripe on median; dark area along distal margin full width and extending above marginal carina; posterior of anteclypeus and postclypeus dark brown, their anterior pale yellow, with heavier dark lines in dividing sutures between sclerites continuing along lateral marginal carina and connecting with frontoclypeal suture across twin depressions of anteclypeus; dorsum of frons with basal 1/3 dark brown, anterior 2/3 yellow, transverse brown stripe of frontoclypeal suture wide and continuous; vertex dark brown with yellow



spot in median depression of ocellar ridge; twin prominences on ocellar ridge smaller, lower and less prominent than in *sigmastylus*; occiput more or less tumid but variable, median yellow spot reduced or wanting; rear of head dark brown.

**Thorax:** Prothorax anterior and posterior pronotum all brown, median lobe with lateral yellow spots; postepimeral stripe with yellow median, marginal carinae brown; proepimeron largely brown; proepisternum light to dark brown medially with yellow ventral margins; pterothorax (Fig. 2) with darker areas more melanic and pale areas more reduced than in *sigmastylus*; mesotergum median yellow reduced, adjacent sclerites entirely without yellow; mesothoracic carina variable, sometimes without median yellow spot, anterodorsal yellow stripes widely interrupted at median; mesanepisternal yellow stripes shorter, narrower and more widely separated from yellow mesothoracic collar than in *sigmastylus*, not reaching antealar carina above; mesanepisternal lateral yellow stripes expanded above and below, narrowed medially, and may be completely interrupted; yellow areas of episterna and epimera reduced and brown borders of sutures widened to enclose spiracle; brown border of interpleural sutures expanded below, median yellow area reduced or obsolete, dorsolateral carina and antealars distinctly melanic; thoracic venter pale gray.

**Legs:** Coxae brown anteriorly, yellow on flexor surface; trochanters entirely brown; prothoracic femora brown laterally, flexor surface yellow; tibiae and tarsi black, tibial keel tan, 0.7 mm long (0.6 mm in *sigmastylus*); pterothoracic femora dark brown, tibiae and tarsi black, hind tibiae 4.95 mm long.

**Wings:** Venation black, more dense and with more intercalated cells than in *sigmastylus*; Pt membrane brown; Fw Ax 11-12, first and fifth thickened, Hw Ax 7-7, Fw Px 9-9, Hw Px 8-8; triangles, subtriangles and supratrangles uncrossed; basal subcostal crossvein absent; outer side angulation of Fw triangle less pronounced than in *sigmastylus*; bridge crossveins 4-5/3-4.

**Abdomen:** Largely black, pale markings less extensive than in *sigmastylus*; S1 yellow transversely on dorsum, venter and ventrolateral 2/3, brown on dorsolateral 1/3; S2 brownish black on dorsum with full length dorsomedian yellow stripe, anterior ventrolateral and auricles yellow, venter and secondary genitalia dark brown; S3-7 black with reduced laterobasal yellow spots not connected across meson; S8 largely black, laterobasal yellow reduced and irregular, a narrow ventrolateral yellow stripe above blackish carina; S9 black on dorsum, ventrolaterally brownish, only a yellow dash posterior to basal intersegmental carina; intersegmental conjunctivae between S2-6 brown, between S7-10 yellow; S10 entirely black.

**Terminalia:** The distinctive shape and dimensions of anal appendages furnish the best characters for separation of the two species; cerci in dorsal view (Fig. 9) slimmer throughout, length 1.33; section proximad of ventrolateral denticle longer and less broadened, ca 0.3 mm wide at base; in lateral view (Fig. 10) ventrolateral denticle at ca 1/2 length; epiproct in ventral view (Fig. 11) longer than wide, median cleft "V" shaped, 0.36 mm deep, apices parallel or only slightly divergent, spread at apices is 0.76.

**Secondary genitalia:** Anterior hamules in lateral view (Fig. 16) typical gomphid 'thumb and knuckles' type, not noticeably distinctive from *sigmastylus*; posterior hamules in oblique lateral view (Fig. 16), with apical transverse excavation ('neck') longer, thickness of surrounding carina reduced, and mesally directed spine

shorter and less acuminate than in *sigmastylus*; apex of hamule rounded rather than squarely truncate; penis vesicle in ventral view (Fig. 15) more tumid, median cleft shallower, anteriolateral lobes shorter.

**Measurements [mm]:** The measurements provided are the mean of 159 specimens. Slightly smaller than *sigmastylus*; total length 34.5; abdomen length 24.17; cerci 1.33; epiproct length 1.0, width at apices 0.88, depth of cleft 0.340; hind femora 4.9; Hw length 20.5; Pt 2.3-2.4/2.7-2.8.

## Female

**Measurements and color:** Dimensions and body patterns of thorax, wings, legs and abdomen largely similar to male.

**Head:** Sculpturing of vertex fairly uniform throughout entire range; prominences and ridges usually less prominent than in *sigmastylus*.

**Genitalia:** Vulvar lamina (Fig. 18) ca 1/4 length of S9 sternum, median cleft minutely "U" shaped at juncture of lobes, lobe apices more acute and tips more divergent than in *sigmastylus*.

Table 2. Diagnostic characters of North American *Stylogomphus* taxa.

Morphological character	<i>sigmastylus</i> sp. nov.	<i>albistylus</i>
Cerci, basal of ventrolateral denticles	Shorter and thicker, width and length ca equal (Fig. 3)	Longer and thinner, length 1.5 times width (Fig. 9)
Epiproct	Wider than long, apices widely flaring; median cleft U-shaped with depth < 0.25 length (Fig. 5)	Longer than wide, apices parallel to slightly spread; median cleft V-shaped with depth ca 0.4 length (Fig. 11)
Posterior hamules	Apex carina thicker, ca 0.5 of excavated 'neck' length (Fig. 14)	Apex carina thinner, ca 0.33 of excavated 'neck' length (Fig. 16)
Ventrolateral denticles of cerci	Located at 0.3 appendage length (Fig. 4)	Located at 0.5 appendage length (Fig. 10)
Vulvar lamina	Cleft between lobes V-shaped with rounded apices (Fig. 17)	Cleft between lobes U-shaped with apices acute and directed slightly outward (Fig. 18)
Prementum	Distal widened portion longer than wide, lateral edges slightly convex (Fig. 19)	Distal widened portion ca equal in length and width, lateral edges ca parallel (Fig. 21)
Labial palp	Denticles smaller, usually 6 in number (Fig. 20)	Denticles larger, usually 5 in number (Fig. 22)

## Larva

**Head:** Labium compared with *sigmastylus*: prementum in ventral view (Fig. 21) shorter, usually without slightly concave lateral edges in distal half, width to length ratio ca equal, narrowed proximal section shorter and more abruptly narrowed; labial palp (Fig. 22) with distal tooth usually 'single-pointed', following teeth normally 4-5, larger and quadrate and usually set in a curved line.

**Abdomen and terminalia:** Not noticeably different from *sigmastylus*.

**Measurements [mm]:** Total length ca 15.7-17.1; abdomen ca 10.0-11.8;  $n = 78$ .

## DISCUSSION

### Distribution

The distributional range of *Stylogomphus sigmastylus* includes Alabama, Arkansas, Indiana, Kansas, Kentucky, Missouri, North Carolina, Oklahoma, Tennessee and Virginia (Fig. 23). The largest populations occur in the Ozark Plateau of Arkansas and Missouri and Interior Low Plateaus of Kentucky and Tennessee, but it appears to be completely absent in lowland areas bordering the Mississippi River. The range of *S. albistylus* is more extensive (Fig. 23). In Canada it includes New Brunswick, Nova Scotia, Ontario and Quebec, and in the United States Alabama, Georgia, Kentucky, Maine, Maryland, Massachusetts, Michigan, New Hampshire, New Jersey, New York, North Carolina, Ohio, Pennsylvania, Tennessee, Vermont, Virginia, West Virginia and Wisconsin. The range of *S. albistylus* essentially surrounds *S. sigmastylus* on the north, east and south. The two species are parapatric in an area from southwestern Virginia south to North Carolina, west to northwestern Alabama and north to south-central Kentucky. *S. albistylus* shows evidence of a population concentration along the Appalachian Mountains from Georgia to Maine, but tends to be rarer along the Atlantic Coastal Plain. Existing literature records for *S. albistylus* in Arkansas, Indiana, Kansas, Missouri and Oklahoma (Needham & Westfall 1955; Dunkle 2000; Needham et al. 2000; Curry 2001) are erroneous and hereafter should be regarded as *S. sigmastylus*.

### Evidence of hybridization

Our observations indicate most Gomphidae species exhibit considerable morphological variation, especially when they are geographically widely distributed, and this holds true for both *S. sigmastylus* and *S. albistylus*. Most *S. sigmastylus* specimens we have examined appear to fall within a typical range of gomphid specific variation, but an exception was noted in a small number of specimens known from near the center of its range overlap with *S. albistylus*. We believe the evidence indicates *S. albistylus* × *sigmastylus* hybridization.

The intermediate specimens in question are from historical collections made by E.B. Williamson from Kentucky: Rockcastle Co., 2 ♂, Livingston, 23 vi 1904, deposited in UMMZ, and by S.W. Dunkle and M.J. Westfall from Tennessee:

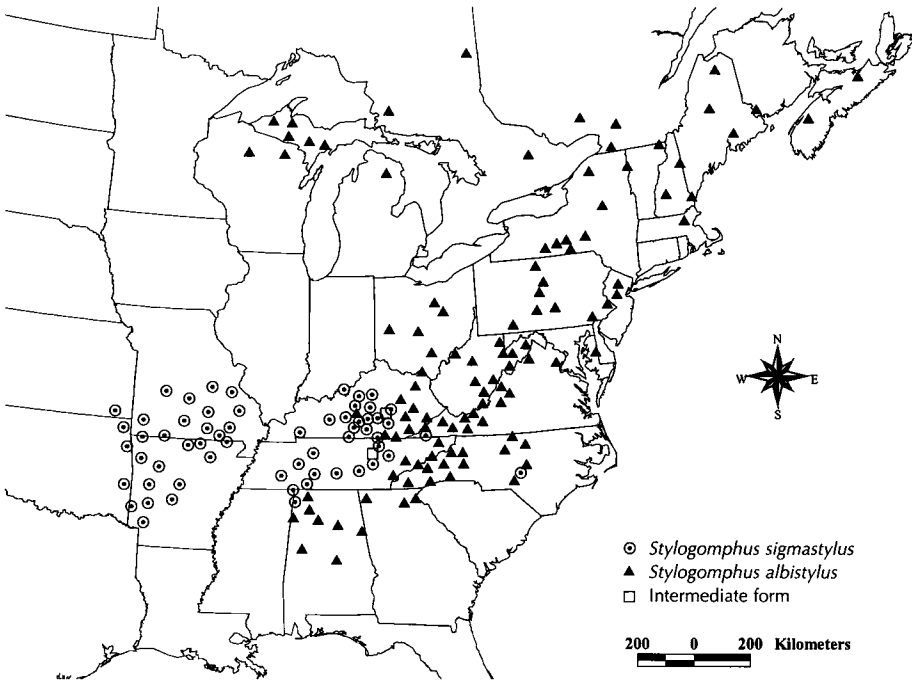


Figure 23: Distribution of *Stylogomphus sigmastylus* sp. nov. and *S. albistylus* in North America.

Cumberland Co., 8 ♂, 2 ♀, Caney Fork River at US 70, W of Crossville, 13 vi 1978, deposited in FSCA (Fig. 23). The most significant features of these specimens are: (1) cerci with ventrolateral denticle at ca 0.4 appendage length; (2) epiproct with depth of median cleft ca 0.26 mm; and (3) apical spread of epiproct 0.9 mm. These features are approximately halfway between typical examples of *S. sigmastylus* and *S. albistylus* (Figs 6-8).

Requirements for hybridization postulates that two parapatric species closely related genetically come in contact with each other at locations where one species is dominant and the other is rare and sporadic. Any resulting issue would be a one-time occurrence, unable to reproduce and maintain a viable population of the variant. These are the presumptive circumstances that likely produced the intermediate forms in question. During the past twenty years the senior author has collected and made observations at both locations where the historical specimens were collected, but has found only typical *S. sigmastylus* occurring there at present. Hybridization in Odonata appears to be uncommon. It has been infrequently observed in the gomphid genus *Ophiogomphus* Selys, 1854 (T.W. Donnelly pers. comm.) and occurs most often in the libellulid genus *Sympetrum* Newman, 1833 (Carle 1993). This is apparently the first reported instance in the Octogomphini tribe. Specimens of the variant form are not designated paratypes of *S. sigmastylus*.

## Biology and habitat

The biology and habitat of *S. albistylus* are very similar to *S. sigmastylus* (Walker 1958; Dunkle 2000; Needham et al. 2000). Based on collection data from the specimens examined during this study, *S. albistylus* flies from early April (Alabama) until late August (North Carolina).

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